

Introduction

A multi-agency, multi-disciplinary study was conducted during the fall of 2001 to examine the movements of hatchery-reared juvenile Chinook salmon (*Oncorhynchus tshawytscha*) released in the Sacramento River immediately upstream of its junction with the Delta Cross Channel (DCC). The DCC is equipped with gates which when open divert water from the Sacramento River into the interior Delta in order to meet water quality requirements in the Delta, and when closed can serve to keep out-migrating juvenile salmon from being diverted into the Delta. The survival of juvenile salmon in the Delta is believed to be significantly less than those which do not enter the Delta (Newman and Rice 1997; Brandes and McLain 2001).

The goal of the study was to determine the effects of time of day and tidal phase on the downstream movement of the juvenile salmon into the DCC when the gates were open. The study was designed to evaluate the following hypotheses: 1) the movement of juvenile salmon into the DCC is proportional to flow; 2) the movement of juvenile salmon into the DCC is affected by diel period; and 3) the movement of juvenile salmon into the DCC is affected by tidally influenced currents (downstream and upstream flows). In general, previous field and experimental studies show juvenile salmon emigration: 1) is both passive and active; 2) may or may not exhibit diurnal patterns; 3) may or may not be related to temperature or flows; 4) may or may not be related to population density; 5) may be related to photoperiod; and 6) movements are with and against flows or not related to flows (for examples see: Healey 1967; Bjornn 1971; Brannon 1972; Fried *et al.* 1978; Solomon 1978; Stevens and Miller 1983; Healey and Groot 1987; Moore *et al.* 1995; Bradford and Taylor 1997; McCormick *et al.* 1998; Kahler *et al.* 2001; Antonsson and Gudjonsson 2002; Connor *et al.* 2002).

The agencies and organizations involved in the multi-disciplinary study included the U.S. Geological Service (USGS), the California Department of Fish and Game, Natural Resource Scientists Inc., and the U.S. Fish and Wildlife Service (USFWS). This report summarizes only the work conducted in 2001 by the USFWS, which was the coded wire tag (CWT) recovery component of the study. This component used recoveries of CWT tagged juvenile hatchery-reared Chinook salmon to address a portion of the study goal. The primary objectives of the

CWT recovery study component were to estimate the proportion of fish movement into the DCC, and determine if there were any relationships between movement and tidal phase, flow and time of day.

Methods

The CWT recovery component of the study was conducted during two (2) replicates of approximately 36 hours each, from 28 October 28 2001 to 02 November 2001. This time was selected as it was a period of optimal neap tides, resulting in similar tidal profiles during the day and night. Approximately 121,000 CWT juvenile Chinook salmon were released during the study. The fish were brood year 2000, late-fall Chinook raised at the Coleman National Fish Hatchery, located near Redding, California. The fish were divided into four (4) batches, ranging in number from about 29,000 to 33,000, and each batch was tagged with a unique CWT code. All the fish were also marked by removing the adipose fin.

Two (2) batches of fish, each with a unique CWT code, were used for each replicate; the batches were delivered to the release site the day before release. These juvenile Chinook salmon were placed in net pens, measuring 3m by 6m by 3m deep. Net pens were anchored in the river near the bank adjacent to the release site on the Sacramento River, about 4.5 kilometers upstream of the DCC. Prior to the scheduled release time, fish were netted out of the pens and counts were estimated by weight. These fish were then transferred to small portable net pens which were towed to the center of the river where the fish were released by inverting the pens. Each CWT code batch was released in three (3) groups, ranging in size from ~7,000 to ~15,000, resulting in six (6) releases for each replicate. The releases of the fish were matched to tidal stage to facilitate the expected arrival at the junction with the DCC during similar conditions for each replicate. The tidal stage was estimated using measured flow data provided by the USGS (source: Jon Bureau, USGS, Sacramento, CA); downstream flows reflect an ebb tide, and upstream flows reflect a flood tide (Figure 1).

The fish were recovered by conducting midwater trawling simultaneously at two locations; one in the DCC about 460 to 610 meters below the Sacramento River, and the other in the Sacramento River downstream of the DCC and upstream of mouth of Georgiana Slough (Figure

2). The cross-sectional area of the channel at each site differed; the Sacramento River site was about 762m² and the DCC site was about 492m². For each replicate, trawling began at about 7:00am PST shortly after the first releases, in advance of the expected arrival of the fish. Tows were always conducted in an upstream direction on the Sacramento River, and from the east toward the gates in the DCC. In the DCC, the trawling lane was in the middle of the channel. An attempt was made on the Sacramento River to alternate between two distinct trawling lanes, one on the east side and one on the west side of the channel to determine if there was a non-random pattern in the distribution of the fish across the river as fish came through the bend at the DCC. This was done during daylight hours, but at night most of the trawls were conducted in the center of the channel due to safety considerations. Fifteen minute tows were the standard, but during slack water or upstream flows tows were sometimes shorter due to the need to stay within the trawling area (83% of tows were 15 minutes). Trawling was nearly continuous for approximately 36 hours during each replicate, with only short stops for crew changeovers and logistic considerations (85% of tows were initiated within 15 minutes of the end of the previous tow).

Identical nets were used for trawling at each location. Each net had a mouth opening 3m high by 9m wide, was 7m long, and tapered towards the cod end. Each of the four sides of the nets was constructed of six panels, decreasing in mesh size towards the cod end. The panels ranged from 10.16cm to 1.27cm stretch mesh, and the cod end was constructed of 0.64cm stretch knotless mesh. The mouth of the net was opened by the force of water against depressors attached to the bottom corners of the mouth and against hydrofoils attached to the top corners of the mouth. The nets were attached to the trawling vessels by cables and were fished at the surface approximately 46m behind the vessels. The vessels were not identical, but the nets and trawling methods were identical so any vessel effects should be minimal.

Current meters were used to measure the length of the water sampled, and this value was used along with the estimated effective mouth opening (18.58m², which is derived from the actual shape of the mouth during sampling) to estimate the volume of water sampled. All fish captured were identified to species and measured to fork length, and recorded by tow. All juvenile Chinook salmon with their adipose fin removed were collected, and all of these fish were

examined for CWTs. If a CWT was present, it was removed and read. All data were entered into an Microsoft Access database.

Results

Replicate 1

Releases: All of the releases occurred on 29 October 2001. The first group of fish was released at 05:29 (all times are PST) and the last group was released at 22:22. The average group size was 9,585 (standard deviation = 3,322) and a total of 57,512 fish was released (the numbers of fish released were estimates based on the weight and an estimate of number of fish per unit weight provided by the hatchery). The estimated tidal stage and time of release are illustrated in Figure 1, and additional details on the size of the fish groups are provided in Table I.

Recoveries: Trawling began at 07:02 and 07:21 at the Sacramento River trawl site (SR027) and at the DCC trawl site (XC001), respectively, on 29 October 2001, and continued until 12:02 at the Sacramento River and until 11:59 at the DCC on 30 October 2001. Sixty-nine tows were conducted at the Sacramento River and 68 tows were conducted at the DCC. Details on time, effort, numbers of CWT fish captured, catch/m³, and associated statistics are given in Table IIa-b.

Captures of both CWT groups at the Sacramento River were initially low until about 2.5 hours after sunset, and were relatively high until sunrise. After sunrise, captures returned to low levels. A total of 402 marked fish were captured at the Sacramento River, but only 395 CWTs were recovered (note: the differences in the number of marked fish and number of CWTs recovered were due to CWT shedding, CWT loss, and unreadable tags). There were no captures of any marked fish at the DCC until about two hours after sunset, and only a few were captured after sunrise. A total of 75 marked fish were captured at the DCC, but only 71 CWTs were recovered. It is important to note there were no captures of either CWT code at the Sacramento River until after a group of each CWT code was released, and no captures of either CWT code at the DCC until after two groups of each CWT code were released.

Replicate 2

Releases: The first five releases occurred on 01 November 2001 and the sixth release occurred on 02 November 2002. The first group of fish was released at 07:07 and the last group was released at 01:05. The average group size was 10,548 (standard deviation = 889) and a total of 63,288 fish were released. The estimated tidal stage and time of release are illustrated in Figure 1, and additional details on the size of the fish groups are provided in Table I.

Recoveries: Trawling began at 07:14 and 07:34 at the Sacramento River and at the DCC, respectively, on 01 November 2001, and continued until 11:10 at the Sacramento River and until 10:36 at the DCC on 02 November 2001. Sixty-eight tows were conducted at the Sacramento River and 66 tows were conducted at the DCC. Details on time, effort, numbers of tagged fish captured, catch/m³, and associated statistics are given in Table IIc-d.

Captures of both CWT groups at the Sacramento River were initially low until sunset, and were relatively high until about 2.5 hours before sunrise, and then began declining until sunrise when they essentially stopped. A total of 812 marked fish were captured, but only 808 CWTs were recovered. Few captures of marked fish occurred at the DCC; only 34 were recovered, and all the recoveries began about two hours after sunset and ended at sunrise. Coded wire tags were recovered from all of the 34 marked fish captured at the DCC. It is important to note, that somewhat similar to the captures observed in Replicate 1, there were no captures of either CWT code at the Sacramento River until after three groups were released, and almost no captures of either CWT code at the DCC until after two groups of each CWT code were released.

Data Analysis

The catch/m³ by tow of the marked and tagged fish was not normally distributed (Figure 3). Therefore, data were log-transformed and re-plotted (the catch/m³ of tows with zero catch were removed for clarity). Interestingly, the transformed data exhibited a bi-modal distribution (Figure 4); all tows with one to two recoveries and some with three or four recoveries were in one mode, while only tows with three or more recoveries were in the other mode. This bi-modality may indicate there was a functional difference which caused this pattern, such as some behavioral difference between large and small groups of fish. Alternatively, there may be a mathematical

explanation. This pattern was more prevalent at night (Figure 5) and did not appear to be influenced by tidal conditions.

Because data were not normally distributed, a non-parametric test (two-way Kolmogorov-Smirnov) was used to evaluate differences in the cumulative distributions of the recovery (catch/m³) by tow of the two CWT codes at each trawl site by Replicate. During Replicate 1, the cumulative distributions of the recoveries of the two CWT codes differed significantly at each trawl site (SR027, $p < 0.004$; XC001, $p < 0.001$), and displayed an interesting relationship with the cumulative number of fish released; recoveries at the Sacramento River were low until more than half the fish were released, and recoveries at the DCC were low until after all the fish were released (Figure 6a-b). The cumulative distributions of the recoveries of the two CWT codes during Replicate 2 differed significantly at each trawl site (SR027, $p < 0.001$; XC001, $p < 0.005$), and displayed the same relationship with the cumulative number of fish released that occurred during Replicate 1; recoveries at the Sacramento River were low until more than half the fish were released, and recoveries at the DCC were low until after all the fish were released (Figure 7a-b). It could be argued that the differences in the time of release of each CWT code influenced the distribution pattern of cumulative recovery rate for the respective CWT code, therefore resulting in the observed significant differences between the recovery rates for each CWT code. But given the general lack of recoveries until after at least more than half the fish of each CWT code pair were released (Figures 6 and 7), this is unlikely.

Since the recovery rates of the CWT codes were significantly different, it may be inappropriate to pool recoveries of the CWT codes to evaluate the effects of physical and temporal factors on recovery rates. Alternatively, the difference in recovery rates may be a consequence of overall low numbers of recoveries. Historically, from 1978 through 2003, recoveries of CWT juvenile salmon in the Sacramento-San Joaquin Delta were low and the variability among recoveries was large; the average proportion recovered was 0.00086 ($s = 0.00138$). Slightly more than 50% of the historical recoveries were $<0.05\%$, and 90% were $<0.20\%$. Although the overall recovery of CWTs of 1.34% observed in the current experiment was higher than 99.80% of all observed recoveries, it was still low, and with low recoveries small increases in the actual number of fish recovered can have large effects. In addition, the large variability in the recoveries of CWTs may

indicate the power of the experiment was relatively low (Peterman 1990). Therefore, the statistically significant differences observed may only be an artifact of low recoveries and large variability in the recoveries.

The power of the experiment was evaluated *a posteriori* by using a bootstrap routine to sub-sample the CWT recovery data from this experiment. The bootstrap routine was designed to mimic the sampling at the DCC of Replicates 1 and 2 (*i.e.*, sampling for 36 hours, two CWT groups). The numbers of CWT fish recovered by tow were randomly selected from the more than 250 samples of the four (4) CWT codes observed at the DCC. The bootstrap routine produced 1000 samples of a replicate; Figure 8 illustrates a histogram of the CWT recoveries at the DCC for the 1000 samples. The mean of the CWT recoveries for Replicate 1 and 2 (50.5) and the bootstrap samples (50.0) are nearly identical, but a Chi-Square test indicates the bootstrap values are significantly different from the expected value (50.5) at $p < 0.001$. This provides further evidence of the large variability in recoveries, and indicates caution must be exercised when evaluating observed significant differences in CWT recoveries.

The difference in catch of tagged and marked fish between day and night was noticeable; nearly all the tagged and marked fish were captured during the night. Overall, 99% of these fish were captured at night. During Replicate 1 at night, 97% of the tagged fish were captured at the Sacramento River, and 96% were captured at the DCC. During Replicate 2 at night, 99% of the tagged fish were captured at the Sacramento River, and 100% were captured at the DCC. The diel pattern in catch is illustrated in Figures 5 and 9, and more details are provided in Table IIa-d.

The proportion of tagged fish caught at each station was compared by examining the total catch/ m^3 and the number of tagged fish caught. There was little difference between the catch/ m^3 and the number caught; during Replicate 1, 83% of the catch/ m^3 and 84% of the total number of tagged fish captured occurred at the Sacramento River. During Replicate 2, 96% of both the catch/ m^3 and the total number of tagged fish captured occurred at the Sacramento River. The difference between the catch/ m^3 of tagged fish by tow at the two stations during each replicate was significantly different (Mann-Whitney U test, $p < 0.0001$), as was the catch/ m^3 at the two stations for Replicates 1 and 2 combined (Mann-Whitney U test, $p < 0.0001$). If the cross-

sectional area of the channel at each station is used with the catch to estimate abundance, the differences between stations will be larger, since the cross-sectional area of the Sacramento River was about 1.6 times that of the DCC. Therefore, the observed differences between the catch at each station should be considered conservative.

Overall, there did not appear to be any clear relationships between the catch of the tagged fish and the tidal cycle (Figure 9). During each replicate, the catch at each station displayed dissimilar patterns; however, patterns observed at each station did show some similarities between replicates. For instance, the catch at the Sacramento River generally shows two peaks at night during each replicate, but the catch during Replicate 2 was greater and the peaks more noticeable than during Replicate 1. The catch of CWT fish at the DCC during Replicate 1 appeared to show a strong peak coincident with the peak of the ebb tide (or the peak of the positive flow) at the DCC, and represented about 53% the catch at both stations during the peak ebb tide. This pattern was not as clear during Replicate 2. The peak in catch coincident with the peak ebb tide during Replicate 2 was of lower magnitude, and represented only about 13% of the catch at both stations during the peak ebb tide.

Visual inspection of Figures 6 and 7 reveals there were no clear relationships between the time fish were released and when they were caught. In any event, determining the release time of most captured fish is not possible. For example, while it can be determined that during Replicate 2 at the Sacramento River fish of CWT code D captured prior to 18:48 on 01 November (when the second release of CWT code D occurred) were released at 09:59 that day, the release time of subsequent captures cannot be determined. Any relationships between release time and capture time were obscured since it was not possible to determine the release time of a captured fish after the second release of a CWT code occurred.

Discussion

Study Hypothesis 1: *The movement of juvenile salmon into the DCC is directly proportional to flow.* The study does not support this hypothesis. The recoveries of tagged juvenile Chinook salmon in the DCC were significantly different between replicates, while the flow patterns were

similar. Figure 9 clearly illustrates the catch of tagged fish was not proportional to flow in either the Sacramento River or the DCC.

Study Hypothesis 2: *The movement of juvenile salmon into the DCC is affected by diel period.* It is clear that the catch of tagged juvenile Chinook salmon at both locations was strongly related to diel period. It is not clear that this is result of fish moving primarily at night; it may be a result of diel patterns in the vertical or horizontal distribution of the fish, or a result of diel patterns in net efficiency. The nets were fished in the upper 3m of the water column, and could not fish along the banks. There is evidence that there may be diel patterns in the horizontal and vertical distribution of juvenile salmon in the Sacramento River system. Sampling during 1973 and 1974 in the Sacramento River near the DCC suggests juvenile salmon occur predominately in the upper 2m of water during the day, do not become benthic during the night but concentrate in the lower part of the water column, occur in highest densities in the portion of the channel where velocities are highest, and move out of nearshore areas after sunset (Schaffter 1980). If this was true during the study, the differences were likely not due to diel patterns in distribution but to net avoidance by the fish. During daylight hours, the net was likely more visible to the fish, and therefore more easily avoided than at night.

Study Hypothesis 3: *The movement of juvenile salmon into the DCC is affected by tidally influenced current.* During Replicate 1, the catch of tagged juvenile Chinook salmon in the DCC appeared to be clearly associated with the peak ebb tide, or the peak positive flow, in the DCC; slightly more than 50% of the total catch during the peak ebb occurred in the DCC. This pattern was not as noticable during Replicate 2; only 13% of the total catch during the peak ebb occurred in the DCC. In addition, the numbers of tagged fish captured in the DCC during Replicate 2 were less than 50% of those captured during Replicate 1.

This study was designed with the expectation, or assumption, that the recoveries of each batch of the tagged fish would not be different within each station during both replicates; however, significant differences were the norm rather than the exception. Significant differences were observed between the recoveries of each tag code at each station during each replicate, and there were significant differences in recoveries between replicates. In fact, no non-significant

differences were observed. Given the problematic nature of recoveries of tagged juvenile salmon in the Sacramento/San Joaquin river system, it is likely the significant differences are not biologically meaningful. However, this also implies that any of the patterns described above (with the exception of the diel pattern in catch) may be due only to chance, and should be interpreted accordingly.

Summary

The objectives of this CWT recovery experiment were to derive estimates of the proportion of released juvenile Chinook salmon which moved into the DCC, and to determine if there were identifiable relationships between the movement and tidal phase and time of day. The findings of this experiment are as follows:

- Overall, the proportion of the released juvenile Chinook salmon recovered in the DCC ranged from 0.04 to 0.16, and averaged about 0.10. The differences between the catch at the Sacramento River and the DCC were significantly different (Mann-Whitney U test, $p < 0.0001$).
- No apparent relationships were consistently identified between the tidal phase and recovery rates of juvenile Chinook salmon at either station, and no apparent relationships could be identified between release times and recovery rates of juvenile Chinook salmon.
- Significantly more CWT juvenile salmon fish were recovered at night during both replicates at both stations. Nearly 99% of the CWT juvenile salmon were captured at night. Daytime captures were insufficient to estimate the proportion of juvenile Chinook salmon which moved into the DCC during the daytime.
- There appeared to be a relationship between the cumulative number of juvenile Chinook salmon released and the recoveries; during Replicate 1 there were few recoveries until more than 50% of the juvenile Chinook salmon were released, and during Replicate 2 there were few recoveries until all the juvenile Chinook salmon were released. This relationship may just be a result of temporal effects (*i.e.*, more captures at night); however, this cannot be determined given the available data.
- Although statistically significant differences in a number of the patterns of recovery of CWT juvenile Chinook salmon were identified, given the low recoveries and large

variance in the recoveries of CWTs, caution must be exercised in evaluating and applying these findings.

The main weakness of this experiment was the low recoveries of CWT juvenile Chinook salmon. This was not unique to this experiment (historically, the average recoveries were even lower). If the recoveries could be increased, it is likely the questionable nature of some of the “statistically significant findings” would be alleviated. Some of these questions may be resolved when these data are incorporated with the hydroacoustic component of the study. If another experimental effort is considered, a unique CWT code should be used for each release, and the temporal coverage of the experiment should be extended (*i.e.*, sampling over several days).

Acknowledgements

Mark Pierce, formerly with the Stockton Fish and Wildlife Office (STFWO), developed and implemented the sampling design for this study. Assistance in developing the sampling design was provided by John Burau of the U.S. Geological Service, Michael Horn of the U.S. Bureau of Reclamation, and Bruce Herbold of the Environmental Protection Agency. This manuscript was improved by the constructive comments and suggestions of B. Herbold and Lia McLaughlin (STFWO). The field crew of the Juvenile Fish Monitoring Program at the STFWO conducted the fish releases, and all of the sampling, data collection, CWT processing, and data entry.

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FINAL DRAFT 07/30/2004 - Movement of Juvenile Chinook Salmon in the Vicinity of the Delta Cross Channel, Fall 2001: Coded Wire Tag Recovery Component. Larry J. Hansen, U.S. Fish and Wildlife Service, Stockton Fish and Wildlife Office, 4001 N. Wilson Way, Stockton, CA 95207. (209)946-6400 ext 309, Larry_Hansen@fws.gov

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Table I. Estimated number of juvenile Chinook salmon released in each group, date and time of release, and coded wire tag (CWT) number code and group code, and the tidal stage existing at the time of release, during each Replicate.

	Replicate 1					
Date	10/29/2001					
Time	5:29	8:55	10:31	17:12	21:09	22:22
Tide Stage	peak ebb	transition ebb to flood		peak ebb	transition ebb to flood	
Group Code	A	B	A	B	A	B
CWT Number	05-06-95	05-06-96	05-06-95	05-06-96	05-06-95	05-06-96
lbs/release	158.0	156.9	158.9	223.6	344.1	261.3
fish/lb	43.8	44.5	43.8	44.5	43.8	44.5
estimated # fish	6920	6982	6960	9950	15072	11628
Total lbs	1302.8					
Total fish	57512					
	Replicate 2					
Date	11/01/2001					11/02/2001
Time	7:07	9:59	11:01	18:48	23:28	1:05
Tide Stage	peak ebb	transition ebb to flood		peak ebb	transition ebb to flood	
Group Code	C	D	C	D	C	D
CWT Number	05-06-97	05-06-98	05-06-97	05-06-98	05-06-97	05-06-98
lbs/release	233.5	231.5	236.6	237.0	213.5	194.0
fish/lb	48.0	46.0	48.0	46.0	48.0	46.0
estimated # fish	11208	10649	11357	10902	10248	8924
Total lbs	1346.1					
Total fish	63288					

Table IIa. Recoveries of marked and coded wire tagged (CWT) juvenile Chinook salmon by tow at station SR027 for Replicate 1. The date and time of each tow, time sampled, m³ sampled, and catch/m³ of all marked fish, and of fish of each CWT group code are given. The time of release, CWT group code, and number of fish released are also given. The mean and standard deviation (s) for time sampled, m³ sampled, and catch/m³ for all marked fish and for each CWT group code are presented for the overall sampling period, and for day and night sampling. Night was defined as the period occurring between sunset to sunrise, and is shaded in the table. The lane trawled is also listed and defined as: E, east side of channel; W, west side of channel; and M, middle of channel.

Fish Release	SR027 - Replicate 1											
Group Code Time Number	Effort					All CWT Recoveries		Recoveries by CWT Group				
	Date	Time	Lane	Minutes	m³	# CWT	CWT/m³	# A	A/m³	# B	B/m³	
A 5:29 6,920	10/29/2001	7:02	E	15.0	8659	0	0	0	0			
	10/29/2001	7:24	W	15.0	17026	0	0	0	0			
	10/29/2001	7:46	E	15.0	12325	0	0	0	0			
	10/29/2001	8:08	W	15.0	8011	0	0	0	0			
	10/29/2001	8:32	E	15.0	19174	0	0	0	0			
	10/29/2001	8:56	W	15.0	13416	0	0	0	0			
B 8:55 6,982	10/29/2001	9:17	E	15.0	12693	0	0	0	0	0	0	
	10/29/2001	9:41	W	15.0	13374	0	0	0	0	0	0	
	10/29/2001	10:03	E	15.0	12982	1	0.000077	1	0.000077	0	0	
A 10:31 6,960	10/29/2001	10:25	W	15.0	12982	1	0.000077	1	0.000077	0	0	
	10/29/2001	10:50	E	15.0	12617	0	0	0	0	0	0	
	10/29/2001	11:41	M	13.0	10644	0	0	0	0	0	0	
	10/29/2001	12:18	E	10.5	10017	0	0	0	0	0	0	
	10/29/2001	12:43	W	11.0	10370	0	0	0	0	0	0	
	10/29/2001	13:06	E	11.0	10878	0	0	0	0	0	0	
	10/29/2001	13:30	W	12.0	10217	0	0	0	0	0	0	
	10/29/2001	14:00	E	11.0	8717	1	0.0001147	1	0.000115	0	0	
	10/29/2001	14:26	W	10.0	9436	0	0	0	0	0	0	
	10/29/2001	14:48	E	11.0	9924	1	0.0001008	1	0.000101	0	0	
	10/29/2001	15:27	M	12.0	8131	0	0	0	0	0	0	
	10/29/2001	15:53	M	14.0	8599	0	0	0	0	0	0	
	10/29/2001	16:21	M	14.0	8410	0	0	0	0	0	0	
	10/29/2001	16:56	M	15.0	9997	1	0.000100	1	0.000100	0	0	
	B 17:12 9,950	10/29/2001	17:23	M	15.0	10271	1	0.000097	1	0.000097	0	0
		10/29/2001	17:49	M	15.0	10395	2	0.000192	2	0.000192	0	0
		10/29/2001	18:10	M	15.0	9893	0	0	0	0	0	0
		10/29/2001	18:37	M	15.0	10410	2	0.000192	0	0	2	0.000192
10/29/2001		18:57	M	15.0	10887	2	0.000184	2	0.000184	0	0	
10/29/2001		19:24	M	15.0	10571	1	0.000095	1	0.000095	0	0	
10/29/2001		19:45	M	15.0	9847	1	0.000102	0	0	1	0.000102	
10/29/2001		20:10	M	15.0	10017	8	0.000799	6	0.000599	2	0.000200	
10/29/2001		20:32	M	15.0	9630	21	0.002181	13	0.001350	6	0.000623	
10/29/2001		20:58	M	15.0	9726	34	0.003496	25	0.002570	7	0.000720	
A 21:09 15,072	10/29/2001	21:19	M	15.0	9291	20	0.002153	8	0.000861	12	0.001292	
	10/29/2001	21:45	M	15.0	12418	1	0.000081	1	0.000081	0	0	
	10/29/2001	22:20	M	15.0	13527	19	0.001405	5	0.000370	14	0.001035	
B 22:22 11,628	10/29/2001	22:41	M	8.0	5107	4	0.000783	1	0.000196	3	0.000587	
	10/29/2001	22:56	M	15.0	13854	17	0.001227	11	0.000794	6	0.000433	
	10/29/2001	23:18	M	15.0	13361	26	0.001946	5	0.000374	20	0.001497	
	10/29/2001	23:39	M	15.0	13282	9	0.000678	5	0.000376	4	0.000301	
	10/30/2001	0:02	M	15.0	12704	7	0.000551	3	0.000236	4	0.000315	
	10/30/2001	0:25	M	13.0	11852	4	0.000337	1	0.000084	3	0.000253	
	10/30/2001	0:48	M	13.0	10545	18	0.001707	11	0.001043	7	0.000664	
	10/30/2001	1:11	M	10.0	9403	10	0.001063	5	0.000532	5	0.000532	
	10/30/2001	1:28	M	15.0	11817	9	0.000762	3	0.000254	6	0.000508	
	10/30/2001	1:51	M	15.0	12424	15	0.001207	5	0.000402	10	0.000805	
	10/30/2001	2:14	M	15.0	10912	21	0.001925	9	0.000825	12	0.001100	
	10/30/2001	2:38	M	15.0	12156	17	0.001398	4	0.000329	13	0.001069	
	10/30/2001	3:14	M	15.0	12778	11	0.000861	4	0.000313	7	0.000548	
	10/30/2001	3:37	M	15.0	12718	9	0.000708	4	0.000315	4	0.000315	
	10/30/2001	4:01	M	15.0	12736	20	0.001570	5	0.000393	15	0.001178	
	10/30/2001	4:25	M	15.0	11581	23	0.001986	9	0.000777	14	0.001209	
	10/30/2001	4:44	M	15.0	10849	9	0.000830	4	0.000369	5	0.000461	
	10/30/2001	5:20	W	15.0	13179	14	0.001062	4	0.000304	10	0.000759	
	10/30/2001	5:43	E	15.0	14653	10	0.000682	4	0.000273	6	0.000409	
	10/30/2001	6:08	W	15.0	12925	27	0.002089	11	0.000851	15	0.001161	
	10/30/2001	6:34	E	15.0	14108	0	0	0	0	0	0	
	10/30/2001	7:01	W	15.0	13260	2	0.000151	0	0	2	0.000151	
	10/30/2001	7:31	E	15.0	14449	0	0	0	0	0	0	
	10/30/2001	7:56	W	15.0	13687	0	0	0	0	0	0	
	10/30/2001	8:20	E	15.0	14469	0	0	0	0	0	0	
	10/30/2001	8:43	W	15.0	11583	1	0.000086	1	0.000086	0	0	
	10/30/2001	9:06	E	15.0	12989	0	0	0	0	0	0	
	10/30/2001	9:29	W	15.0	12111	0	0	0	0	0	0	
	10/30/2001	9:53	E	15.0	13378	0	0	0	0	0	0	
	10/30/2001	10:19	W	15.0	11937	2	0.000168	1	0.000084	1	0.000084	
	10/30/2001	10:49	E	15.0	11520	0	0	0	0	0	0	
	10/30/2001	11:18	W	15.0	13241	0	0	0	0	0	0	
	10/30/2001	11:47	E	15.0	12665	0	0	0	0	0	0	
All	Total			983.5	803715	402		179		216		
	Mean			14.3	11648	5.83	0.000510	2.59	0.000233	3.43	0.000294	
	s			1.6	2199	8.52	0.000760	4.27	0.000410	5.05	0.000419	
Day	Total			504.5	427994	10		7		3		
	Mean			14.0	11889	0.28	0.000024	0.19	0.000018	0.10	0.000008	
	s			1.7	2475	0.57	0.000048	0.40	0.000037	0.40	0.000031	
Night	Total			479.0	375721	392		172		213		
	Mean			14.5	11385	11.88	0.001041	5.21	0.000468	6.45	0.000553	
	s			1.5	1856	9.02	0.000818	5.00	0.000498	5.42	0.000440	

Table IIB. Recoveries of marked and coded wire tagged (CWT) juvenile Chinook salmon by tow at station XC001 for Replicate 1. The date and time of each tow, time sampled, m³ sampled, and catch/m³ of all marked fish, and of fish of each CWT group code are given. The time of release, CWT group code, and number of fish released are also given. The mean and standard deviation (s) for time sampled, m³ sampled, and catch/m³ for all marked fish and for each CWT group code are presented for the overall sampling period, and for day and night sampling. Night was defined as the period occurring between sunset to sunrise, and is shaded in the table.

Fish Release Group Code Time Number	XC001 - Replicate 1									
	Effort				All CWT Recoveries		Recoveries by CWT Group			
	Date	Time	Minutes	m ³	# CWT	CWT/m ³	# A	A/m ³	# B	B/m ³
A 5:29 6,920	10/29/2001	7:21	15	11462	0	0	0	0	0	0
	10/29/2001	7:47	15	10571	0	0	0	0	0	0
	10/29/2001	8:10	15	11277	0	0	0	0	0	0
	10/29/2001	8:33	15	7352	0	0	0	0	0	0
B 8:55 6,982	10/29/2001	8:56	15	10016	0	0	0	0	0	0
	10/29/2001	9:17	15	10875	0	0	0	0	0	0
	10/29/2001	9:39	15	8576	0	0	0	0	0	0
	10/29/2001	10:15	15	9678	0	0	0	0	0	0
A 10:31 6,960	10/29/2001	10:36	15	10947	0	0	0	0	0	0
	10/29/2001	10:58	15	10504	0	0	0	0	0	0
	10/29/2001	11:19	15	9895	0	0	0	0	0	0
	10/29/2001	11:40	15	8530	0	0	0	0	0	0
	10/29/2001	12:01	15	9815	0	0	0	0	0	0
	10/29/2001	12:21	15	10554	0	0	0	0	0	0
	10/29/2001	12:43	15	9985	0	0	0	0	0	0
	10/29/2001	13:03	15	10174	0	0	0	0	0	0
	10/29/2001	13:25	15	10150	0	0	0	0	0	0
	10/29/2001	13:47	15	9639	0	0	0	0	0	0
	10/29/2001	14:07	15	10518	0	0	0	0	0	0
	10/29/2001	14:40	15	11187	0	0	0	0	0	0
	10/29/2001	15:24	15	11851	0	0	0	0	0	0
	10/29/2001	15:45	15	11332	0	0	0	0	0	0
	10/29/2001	16:08	15	9683	0	0	0	0	0	0
	10/29/2001	16:30	15	8552	0	0	0	0	0	0
	10/29/2001	16:53	15	10886	0	0	0	0	0	0
	10/29/2001	17:25	15	10978	0	0	0	0	0	0
	10/29/2001	17:53	14	12804	0	0	0	0	0	0
	10/29/2001	18:17	15	11293	0	0	0	0	0	0
B 17:12 9,950	10/29/2001	18:42	15	12441	0	0	0	0	0	0
	10/29/2001	19:07	15	10805	1	0.000093	1	0.000093	0	0
	10/29/2001	19:44	15	10558	0	0	0	0	0	0
	10/29/2001	20:11	15	15266	0	0	0	0	0	0
	10/29/2001	20:38	15	14227	0	0	0	0	0	0
	10/29/2001	21:04	15	12541	1	0.000080	1	0.000080	0	0
A 21:09 15,072	10/29/2001	21:34	15	14050	1	0.000071	0	0	0	0
	10/29/2001	22:15	15	15528	0	0	0	0	0	0
	10/29/2001	22:37	11	7490	0	0	0	0	0	0
B 22:22 11,628	10/29/2001	23:16	15	10244	0	0	0	0	0	0
	10/29/2001	23:37	15	8364	1	0.000120	1	0.000120	0	0
	10/30/2001	0:02	15	11815	2	0.000169	0	0	2	0.000169
	10/30/2001	0:24	15	11439	12	0.001049	11	0.000962	1	0.000087
	10/30/2001	0:47	15	10581	9	0.000851	8	0.000756	1	0.000095
	10/30/2001	1:10	15	12810	15	0.001171	14	0.001093	0	0
	10/30/2001	1:31	15	12947	10	0.000772	9	0.000695	0	0
	10/30/2001	1:54	15	12108	2	0.000165	2	0.000165	0	0
	10/30/2001	2:29	15	12442	1	0.000080	0	0	1	0.000080
	10/30/2001	2:49	15	11593	4	0.000345	1	0.000086	3	0.000259
	10/30/2001	3:17	15	11910	2	0.000168	0	0	2	0.000168
	10/30/2001	3:33	15	13071	1	0.000077	1	0.000077	0	0
	10/30/2001	4:05	15	12520	1	0.000080	1	0.000080	0	0
	10/30/2001	4:28	15	12630	1	0.000079	1	0.000079	0	0
	10/30/2001	4:49	15	11971	0	0	0	0	0	0
	10/30/2001	5:31	10	19226	2	0.000104	1	0.000052	1	0.000052
	10/30/2001	5:52	15	11004	3	0.000273	1	0.000091	2	0.000182
	10/30/2001	6:19	15	8886	3	0.000338	2	0.000225	1	0.000113
	10/30/2001	6:56	15	9646	1	0.000104	1	0.000104	0	0
	10/30/2001	7:19	15	9680	0	0	0	0	0	0
	10/30/2001	7:42	15	10093	0	0	0	0	0	0
	10/30/2001	8:18	15	10258	0	0	0	0	0	0
	10/30/2001	8:40	15	9083	0	0	0	0	0	0
	10/30/2001	9:01	15	9739	0	0	0	0	0	0
	10/30/2001	9:25	15	9930	0	0	0	0	0	0
	10/30/2001	9:47	15	10491	0	0	0	0	0	0
	10/30/2001	10:11	15	10724	1	0.000093	0	0	0	0
	10/30/2001	10:34	15	11226	1	0.000089	1	0.000089	0	0
	10/30/2001	10:57	15	11038	0	0	0	0	0	0
	10/30/2001	11:20	15	10886	0	0	0	0	0	0
	10/30/2001	11:44	15	12140	0	0	0	0	0	0
All	Total		1010.0	752486	75		57		14	
	Mean		14.9	11066	1.10	0.000094	0.84	0.000071	0.22	0.000019
	s		0.8	1887	2.81	0.000234	2.54	0.000211	0.61	0.000053
Day	Total		570.0	388941	3		2		0	
	Mean		15.0	10235	0.08	0.000008	0.05	0.000005	0.00	0.000000
	s		0.0	980	0.27	0.000026	0.23	0.000022	0.00	0.000000
Night	Total		440.0	363545	72		55		14	
	Mean		14.7	12118	2.40	0.000203	1.83	0.000155	0.47	0.000040
	s		1.2	2226	3.87	0.000323	3.61	0.000299	0.82	0.000071

Table IIc. Recoveries of marked and coded wire tagged (CWT) juvenile Chinook salmon by tow at station SR027 for Replicate 2. The date and time of each tow, time sampled, m³ sampled, and catch/m³ of all marked fish, and of fish of each CWT group code are given. The time of release, CWT group code, and number of fish released are also given. The mean and standard deviation (s) for time sampled, m³ sampled, and catch/m³ for all marked fish and for each CWT group code are presented for the overall sampling period, and for day and night sampling. Night was defined as the period occurring between sunset to sunrise, and is shaded in the table. The lane trawled is also listed and defined as: E, east side of channel; W, west side of channel; and M, middle of channel.

Fish release	SR027 - Replicate 2																
Group Code Time Number	Effort					All CWT Recoveries		Recoveries by CWT Group									
	Date	Time	Lane	Minutes	m³	# CWT	CWT/m³	# A	A/m³	# B	B/m³	# C	C/m³	# D	D/m³		
C 7:07 11,208	11/01/2001	7:14	W	15.0	13858	0	0	0	0	0	0	0	0				
	11/01/2001	7:38	E	15.0	12788	0	0	0	0	0	0	0	0				
	11/01/2001	8:02	W	15.0	12806	0	0	0	0	0	0	0	0				
	11/01/2001	8:24	E	15.0	12251	0	0	0	0	0	0	0	0				
	11/01/2001	8:47	W	15.0	12435	0	0	0	0	0	0	0	0				
	11/01/2001	9:10	E	15.0	12146	0	0	0	0	0	0	0	0				
	11/01/2001	9:32	W	15.0	11583	0	0	0	0	0	0	0	0				
	11/01/2001	9:54	E	15.0	14011	0	0	0	0	0	0	0	0				
D 9:59 10,649	11/01/2001	10:17	W	15.0	13936	0	0	0	0	0	0	0	0	0	0		
	11/01/2001	10:43	W	15.0	12928	0	0	0	0	0	0	0	0	0	0		
	11/01/2001	11:03	E	15.0	13543	0	0	0	0	0	0	0	0	0	0		
	11/01/2001	11:27	W	15.0	12832	0	0	0	0	0	0	0	0	0	0		
C 11:01 11,357	11/01/2001	11:51	E	15.0	12318	0	0	0	0	0	0	0	0	0	0		
	11/01/2001	12:16	W	13.0	11971	0	0	0	0	0	0	0	0	0	0		
	11/01/2001	12:40	E	15.0	12652	0	0	0	0	0	0	0	0	0	0		
	11/01/2001	13:05	W	11.0	10306	0	0	0	0	0	0	0	0	0	0		
	11/01/2001	13:30	E	10.0	10585	0	0	0	0	0	0	0	0	0	0		
	11/01/2001	13:54	W	9.0	8221	0	0	0	0	0	0	0	0	0	0		
	11/01/2001	14:11	E	10.0	8592	1	0.000116	0	0	0	0	1	0.000116	0	0		
	11/01/2001	14:36	W	10.0	9396	0	0	0	0	0	0	0	0	0	0		
	11/01/2001	15:02	E	12.0	8183	0	0	0	0	0	0	0	0	0	0		
	11/01/2001	15:28	E	12.0	7800	0	0	0	0	0	0	0	0	0	0		
	11/01/2001	15:53	E	15.0	7074	0	0	0	0	0	0	0	0	0	0		
	11/01/2001	16:18	E	10.0	6930	0	0	0	0	0	0	0	0	0	0		
	11/01/2001	16:39	E	10.0	8362	0	0	0	0	0	0	0	0	0	0		
	11/01/2001	17:13	E	15.0	9789	26	0.002656	0	0	0	0	14	0.001430	12	0.001226		
	11/01/2001	17:42	E	15.0	9543	49	0.005135	1	0.000105	1	0.000105	26	0.002725	21	0.002201		
	11/01/2001	18:09	E	15.0	9534	71	0.007447	0	0	0	0	39	0.004091	31	0.003252		
	D 18:48 10,902	11/01/2001	18:36	E	15.0	10048	22	0.002190	0	0	0	0	17	0.001692	5	0.000498	
		11/01/2001	18:58	E	15.0	9060	31	0.003422	0	0	0	0	27	0.002980	4	0.000441	
		11/01/2001	19:35	E	15.0	11813	52	0.004402	0	0	1	0.000085	29	0.002455	21	0.001778	
		11/01/2001	19:57	E	10.0	10076	27	0.002680	0	0	1	0.000099	19	0.001886	7	0.000695	
		11/01/2001	20:29	E	15.0	16515	12	0.000727	1	0.000061	0	0	7	0.000424	4	0.000242	
		11/01/2001	20:55	E	15.0	10720	25	0.002332	0	0	1	0.000093	11	0.001026	13	0.001213	
		11/01/2001	21:28	E	15.0	20612	26	0.001261	0	0	2	0.000097	13	0.000631	10	0.000485	
		11/01/2001	22:17	E	15.0	15326	31	0.002023	0	0	0	0	5	0.000326	26	0.001696	
11/01/2001		22:39	E	15.0	16091	43	0.002672	0	0	1	0.000062	6	0.000373	36	0.002237		
11/01/2001		23:02	E	15.0	15254	29	0.001901	0	0	0	0	5	0.000328	24	0.001573		
C 23:28 10,248		11/01/2001	23:25	M	15.0	14749	19	0.001288	0	0	0	0	4	0.000271	15	0.001017	
		11/01/2001	23:47	M	15.0	14065	15	0.001066	0	0	1	0.000071	3	0.000213	10	0.000711	
		11/02/2001	0:08	M	15.0	15349	3	0.000195	0	0	0	0		0	3	0.000195	
		11/02/2001	0:30	M	15.0	16352	8	0.000489	0	0	0	0	2	0.000122	6	0.000367	
D 1:05 8,924	11/02/2001	0:53	M	15.0	14464	2	0.000138	0	0	0	0	1	0.000069	1	0.000069		
	11/02/2001	1:21	M	15.0	15556	8	0.000514	0	0	2	0.000129	4	0.000257	2	0.000129		
	11/02/2001	1:46	W	14.0	13954	11	0.000788	0	0	1	0.000072	10	0.000717		0		
	11/02/2001	2:08	W	14.0	8051	19	0.002360	0	0	0	0	16	0.001987	3	0.000373		
	11/02/2001	2:29	M	13.0	15883	16	0.001007	0	0	0	0	14	0.000881	2	0.000126		
	11/02/2001	2:48	W	10.0	8916	43	0.004823	0	0	0	0	40	0.004487	3	0.000336		
	11/02/2001	3:03	M	12.0	10153	19	0.001871	0	0	1	0.000098	15	0.001477	3	0.000295		
	11/02/2001	3:20	M	12.0	11692	98	0.008382	0	0	1	0.000086	89	0.007612	8	0.000684		
	11/02/2001	3:41	M	12.0	11610	32	0.002756	0	0	1	0.000086	25	0.002153	6	0.000517		
	11/02/2001	4:03	M	12.0	12047	13	0.001079	0	0	0	0	8	0.000664	5	0.000415		
	11/02/2001	4:27	M	12.0	11953	5	0.000418	0	0	0	0	5	0.000418		0		
	11/02/2001	4:49	M	14.0	11344	7	0.000617	0	0	1	0.000088	3	0.000264	3	0.000264		
	11/02/2001	5:27	W	10.0	10985	9	0.000819	1	0.000091	0	0	7	0.000637	1	0.000091		
	11/02/2001	5:49	E	13.0	10985	13	0.001183	0	0	0	0	7	0.000637	6	0.000546		
	11/02/2001	6:13	W	13.0	10985	23	0.002094	1	0.000091	2	0.000182	8	0.000728	12	0.001092		
	11/02/2001	6:36	E	12.0	11886	2	0.000168	0	0	0	0	1	0.000084	1	0.000084		
	11/02/2001	7:00	W	15.0	12895	0	0	0	0	0	0	0	0	0	0		
	11/02/2001	7:25	E	15.0	16009	0	0	0	0	0	0	0	0	0	0		
	11/02/2001	7:49	W	15.0	11806	1	0.000085	0	0	0	0	1	0.000085	0	0		
	11/02/2001	8:19	E	15.0	13885	0	0	0	0	0	0	0	0	0	0		
	11/02/2001	8:43	W	15.0	12075	0	0	0	0	0	0	0	0	0	0		
	11/02/2001	9:06	E	15.0	14826	0	0	0	0	0	0	0	0	0	0		
	11/02/2001	9:33	W	15.0	15238	1	0.000066	0	0	0	0	0	0	1	0.000066		
	11/02/2001	9:58	E	15.0	13651	0	0	0	0	0	0	0	0	0	0		
	11/02/2001	10:21	W	15.0	13939	0	0	0	0	0	0	0	0	0	0		
	11/02/2001	10:55	M	15.0	13948	0	0	0	0	0	0	0	0	0	0		
	All	Total				935.0	831137	812		4		17		482	305		
		Mean				13.8	12223	11.94	0.001047	0.06	0.000005	0.25	0.000020	7.19	0.000651	5.26	0.000415
		s				1.9	2665	18.82	0.001742	0.24	0.000021	0.53	0.000041	13.93	0.001299	8.41	0.000681
	Day	Total				494.0	427667	5		0		0		3	2		
Mean				13.7	11880	0.14	0.000012	0.00	0.000000	0.00	0.000000	0.08	0.000008	0.07	0.000005		
s				2.1	2385	0.42	0.000037	0.00	0.000000	0.00	0.000000	0.28	0.000027	0.26	0.000020		
Night	Total				441.0	403471	807		4		17		479	303			
	Mean				13.8	12608	25.22	0.002211	0.13	0.000011	0.53	0.000042	15.45	0.001374	10.10	0.000774	
	s				1.7	2939	20.53	0.001978	0.34	0.000030	0.67	0.000052	17.19	0.001621	9.42	0.000773	

Table IId. Recoveries of marked and coded wire tagged (CWT) juvenile Chinook salmon by tow at station XC001 for Replicate 2. The date and time of each tow, time sampled, m³ sampled, and catch/m³ of all marked fish, and of fish of each CWT group code are given. The time of release, CWT group code, and number of fish released are also given. The mean and standard deviation (s) for time sampled, m³ sampled, and catch/m³ for all marked fish and for each CWT group code are presented for the overall sampling period, and for day and night sampling. Night was defined as the period occurring between sunset to sunrise, and is shaded in the table.

Fish Release	XC001 - Replicate 2													
Group Code														
Time Number	Effort				All CWT Recoveries		Recoveries by CWT Group							
	Date	Time	Minutes	m ³	# CWT	Tags/m ³	# A	A/m ³	# B	B/m ³	# C	C/m ³	# D	D/m ³
C 7:07 11,208	11/01/2001	7:34	15	8849	0	0	0	0	0	0	0	0		
	11/01/2001	7:58	15	10363	0	0	0	0	0	0	0	0		
	11/01/2001	8:20	15	8918	0	0	0	0	0	0	0	0		
	11/01/2001	8:41	15	9273	0	0	0	0	0	0	0	0		
	11/01/2001	9:03	15	9439	0	0	0	0	0	0	0	0		
	11/01/2001	9:25	15	9799	0	0	0	0	0	0	0	0		
	11/01/2001	9:47	15	8418	0	0	0	0	0	0	0	0		
D 9:59 10,649	11/01/2001	10:09	15	8436	0	0	0	0	0	0	0	0	0	0
	11/01/2001	10:30	15	9469	0	0	0	0	0	0	0	0	0	0
	11/01/2001	10:51	15	9480	0	0	0	0	0	0	0	0	0	0
C 11:01 11,357	11/01/2001	11:14	15	9775	0	0	0	0	0	0	0	0	0	0
	11/01/2001	11:37	15	10081	0	0	0	0	0	0	0	0	0	0
	11/01/2001	11:57	15	9846	0	0	0	0	0	0	0	0	0	0
	11/01/2001	12:29	15	8953	0	0	0	0	0	0	0	0	0	0
	11/01/2001	12:50	15	10985	0	0	0	0	0	0	0	0	0	0
	11/01/2001	13:11	15	10833	0	0	0	0	0	0	0	0	0	0
	11/01/2001	13:33	15	11177	0	0	0	0	0	0	0	0	0	0
	11/01/2001	13:54	15	11960	0	0	0	0	0	0	0	0	0	0
	11/01/2001	14:15	15	11049	0	0	0	0	0	0	0	0	0	0
	11/01/2001	14:35	15	9906	0	0	0	0	0	0	0	0	0	0
	11/01/2001	15:15	15	16487	0	0	0	0	0	0	0	0	0	0
	11/01/2001	15:36	15	15569	0	0	0	0	0	0	0	0	0	0
	11/01/2001	15:56	15	15795	0	0	0	0	0	0	0	0	0	0
	11/01/2001	16:17	14	14891	0	0	0	0	0	0	0	0	0	0
	11/01/2001	16:40	15	15778	0	0	0	0	0	0	0	0	0	0
	11/01/2001	17:01	12	10384	0	0	0	0	0	0	0	0	0	0
	11/01/2001	17:21	15	9871	0	0	0	0	0	0	0	0	0	0
	11/01/2001	17:48	15	14835	0	0	0	0	0	0	0	0	0	0
	11/01/2001	18:10	15	12654	0	0	0	0	0	0	0	0	0	0
	11/01/2001	18:46	15	15670	1	0.000064	0	0	0	1	0.000064	0	0	0
	11/01/2001	19:12	15	14250	0	0	0	0	0	0	0	0	0	0
	11/01/2001	19:36	15	12421	0	0	0	0	0	0	0	0	0	0
	11/01/2001	20:02	15	7489	1	0.000134	0	0	0	1	0.000134	0	0	0
	11/01/2001	20:28	15	10321	0	0	0	0	0	0	0	0	0	0
	11/01/2001	20:53	15	15213	1	0.000066	0	0	0	0	0	0	1	0.000086
	11/01/2001	21:28	15	15948	0	0	0	0	0	0	0	0	0	0
	11/01/2001	22:03	15	9183	0	0	0	0	0	0	0	0	0	0
	11/01/2001	22:22	15	9561	0	0	0	0	0	0	0	0	0	0
C 23:28 10,248	11/01/2001	23:30	15	11744	0	0	0	0	0	0	0	0	0	0
	11/01/2001	23:52	12	10109	0	0	0	0	0	0	0	0	0	0
	11/02/2001	0:15	14	9844	0	0	0	0	0	0	0	0	0	0
	11/02/2001	0:34	15	10093	1	0.000099	0	0	0	0	0	0	1	0.000099
D 1:05 8,924	11/02/2001	0:57	15	9557	0	0	0	0	0	0	0	0	0	0
	11/02/2001	1:16	11	8749	1	0.000114	0	0	0	1	0.000114	0	0	0
	11/02/2001	1:46	15	10744	0	0	0	0	0	0	0	0	0	0
	11/02/2001	2:06	15	11339	2	0.000176	0	0	0	2	0.000176	0	0	0
	11/02/2001	2:27	15	11843	6	0.000507	1	0.000084	1	0.000084	4	0.000338	0	0
	11/02/2001	2:47	15	11962	7	0.000585	0	0	0	7	0.000585	0	0	0
	11/02/2001	3:09	15	11664	2	0.000171	0	0	0	1	0.000086	1	0.000086	0
	11/02/2001	4:01	15	8935	1	0.000112	0	0	0	0	0	0	1	0.000112
	11/02/2001	4:21	15	13419	2	0.000149	0	0	0	1	0.000075	1	0.000075	0
	11/02/2001	4:43	15	9986	2	0.000200	1	0.000100	1	0.000100	0	0	0	0
	11/02/2001	5:23	15	10992	1	0.000091	0	0	0	1	0.000091	0	0	0
	11/02/2001	5:46	15	9808	1	0.000102	0	0	0	0	0	0	1	0.000102
	11/02/2001	6:07	15	10369	5	0.000482	0	0	0	3	0.000289	2	0.000193	0
	11/02/2001	6:30	15	9917	0	0	0	0	0	0	0	0	0	0
	11/02/2001	6:50	15	9625	0	0	0	0	0	0	0	0	0	0
	11/02/2001	7:12	15	9284	0	0	0	0	0	0	0	0	0	0
	11/02/2001	7:37	15	10715	0	0	0	0	0	0	0	0	0	0
	11/02/2001	8:13	15	10134	0	0	0	0	0	0	0	0	0	0
	11/02/2001	8:34	15	11987	0	0	0	0	0	0	0	0	0	0
	11/02/2001	8:56	15	8387	0	0	0	0	0	0	0	0	0	0
	11/02/2001	9:23	15	9729	0	0	0	0	0	0	0	0	0	0
	11/02/2001	9:44	15	9776	0	0	0	0	0	0	0	0	0	0
	11/02/2001	10:07	15	9869	0	0	0	0	0	0	0	0	0	0
	11/02/2001	10:21	15	8499	0	0	0	0	0	0	0	0	0	0
All	Total		978.0	722406	34		2		2		22		8	
	Mean		14.8	10978	0.52	0.000047	0.03	0.000003	0.03	0.000003	0.34	0.000030	0.14	0.000013
	s		0.7	2222	1.34	0.000117	0.17	0.000016	0.17	0.000016	1.09	0.000094	0.39	0.000037
Day	Total		539.0	383451	0		0		0		0		0	
	Mean		15.0	10651	0.00	0.000000	0.00	0.000000	0.00	0.000000	0.00	0.000000	0.00	0.000000
	s		0.2	2249	0.00	0.000000	0.00	0.000000	0.00	0.000000	0.00	0.000000	0.00	0.000000
Night	Total		439.0	338955	34		2		2		22		8	
	Mean		14.6	11299	1.13	0.000102	0.07	0.000006	0.07	0.000006	0.73	0.000065	0.27	0.000025
	s		1.0	2174	1.81	0.000158	0.25	0.000024	0.25	0.000024	1.53	0.000131	0.52	0.000050

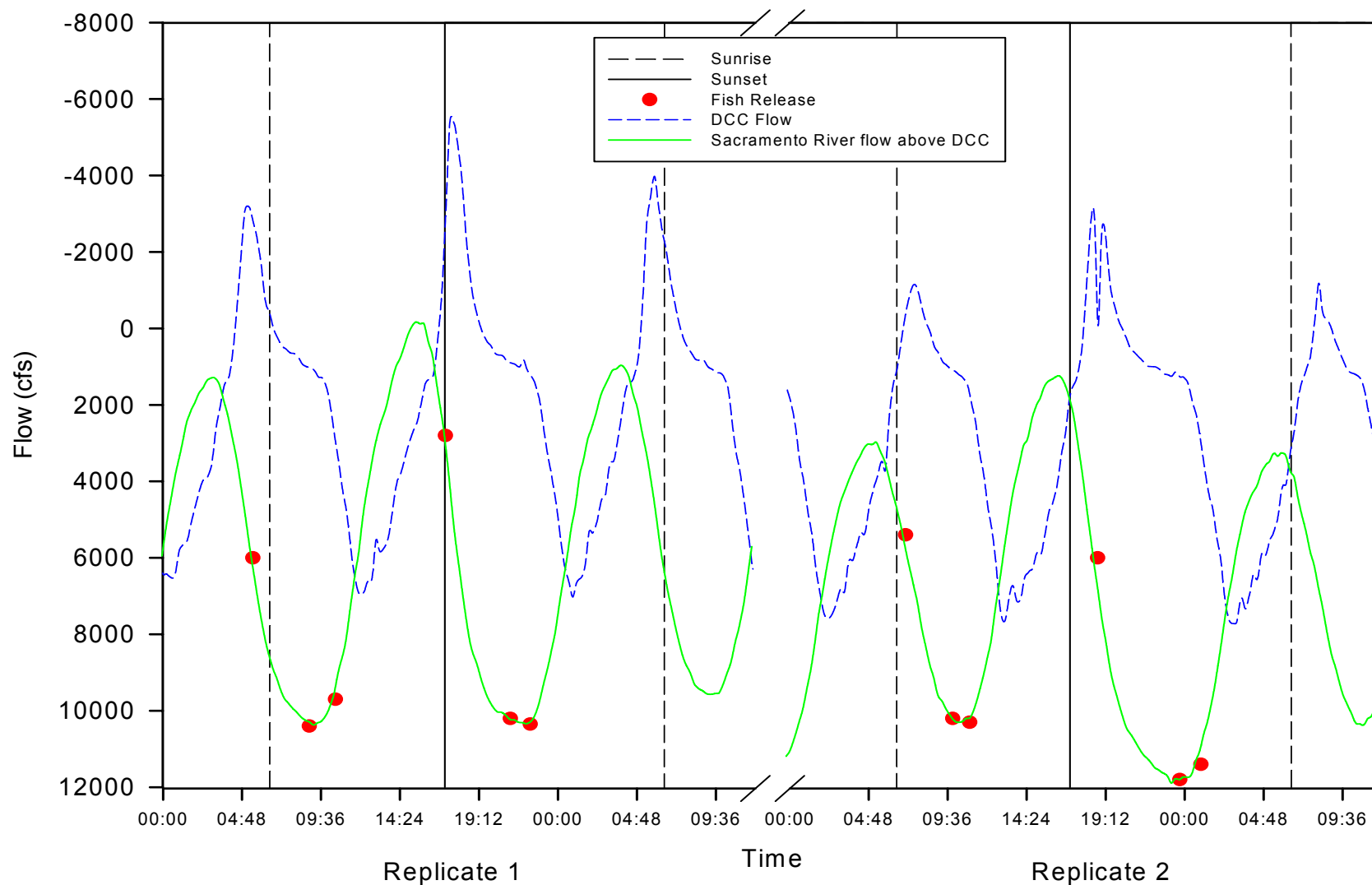


Figure 1. Estimated tidal conditions, based on measured flow in the Sacramento River above the Delta Cross Channel (DCC) in the DCC, and the release time of each group are shown. The time of sunrise and sunset are also shown. Note the break in the X axis which reflects the sampling periods of the two replicates. The scale of the left axis was reversed to indicate the relative tidal conditions; negative flows are associated with a flood (high) tide, and positive flows are associated with an ebb (low) tide.

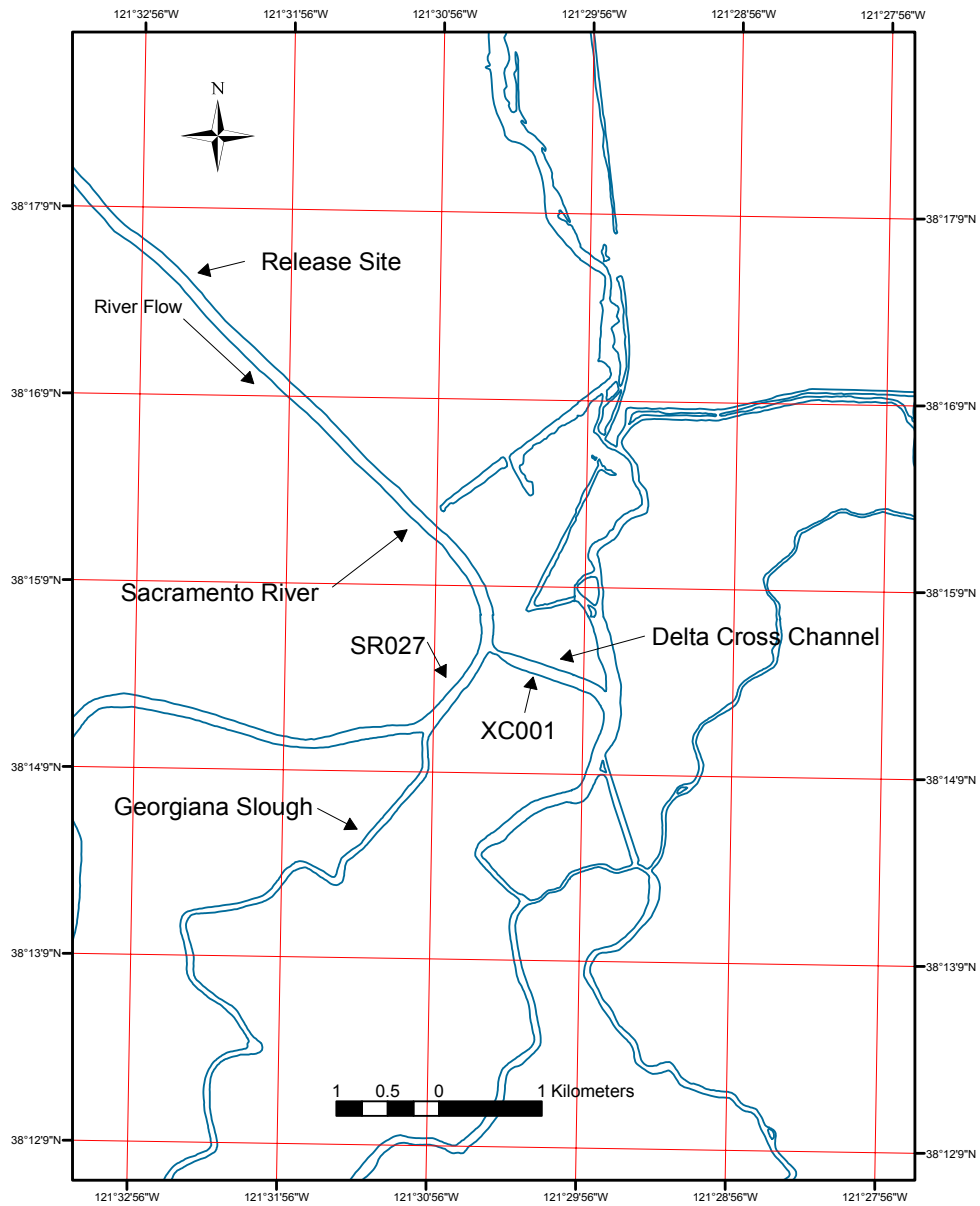


Figure 2. Approximate locations of the release site and trawl station SR027 on the Sacramento River, and of the trawl station XC00w on the Delta Cross Channel.

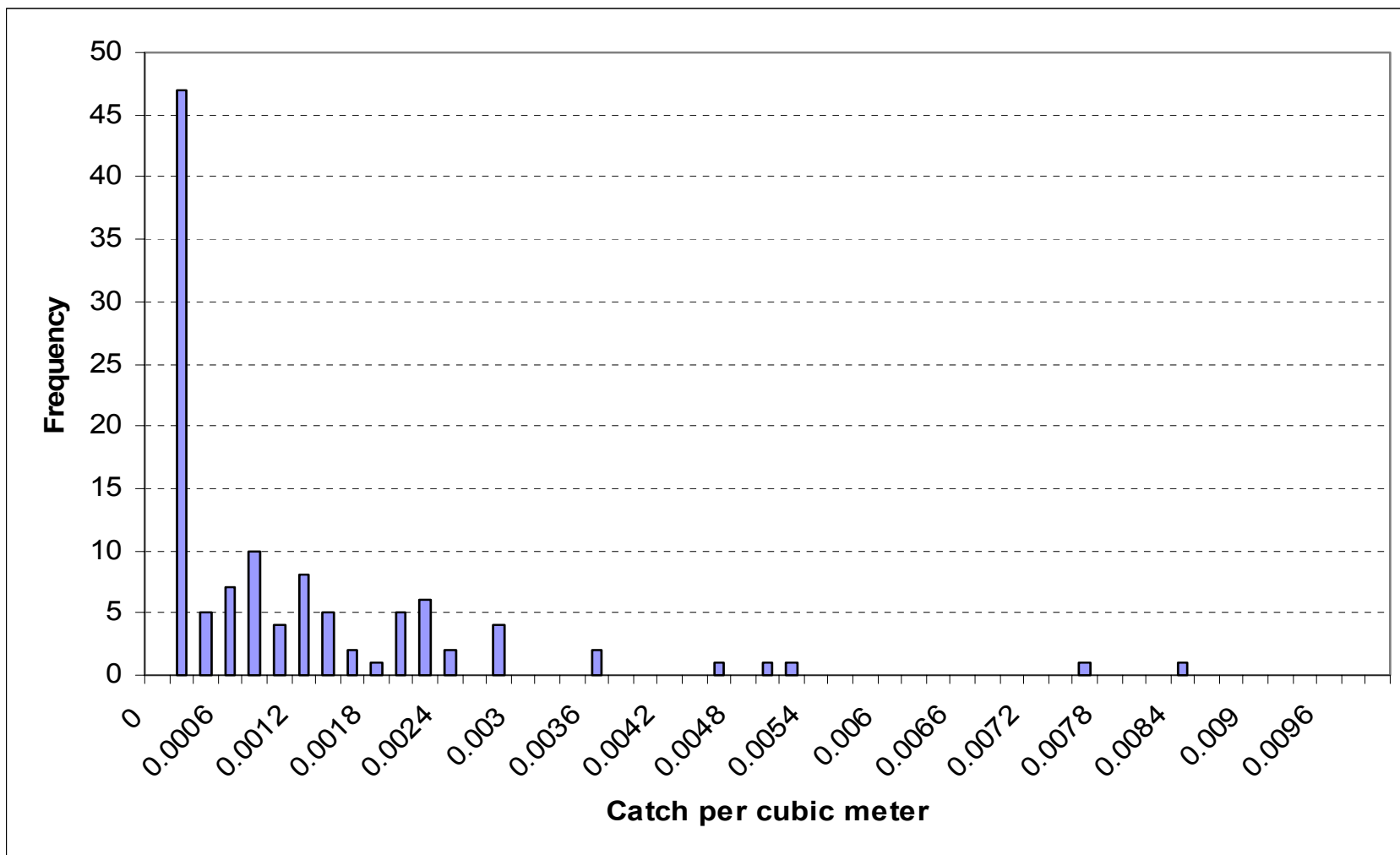


Figure 3. Frequency distribution of the catch/m³ by tow of marked and coded wire tagged (CWT) juvenile Chinook salmon for sampling at both trawl stations (SR027 and XC001) during both Replicate 1 and Replicate 2 for all tows where at least one marked or CWT fish was caught. Bins are based on an interval of 0.0002.

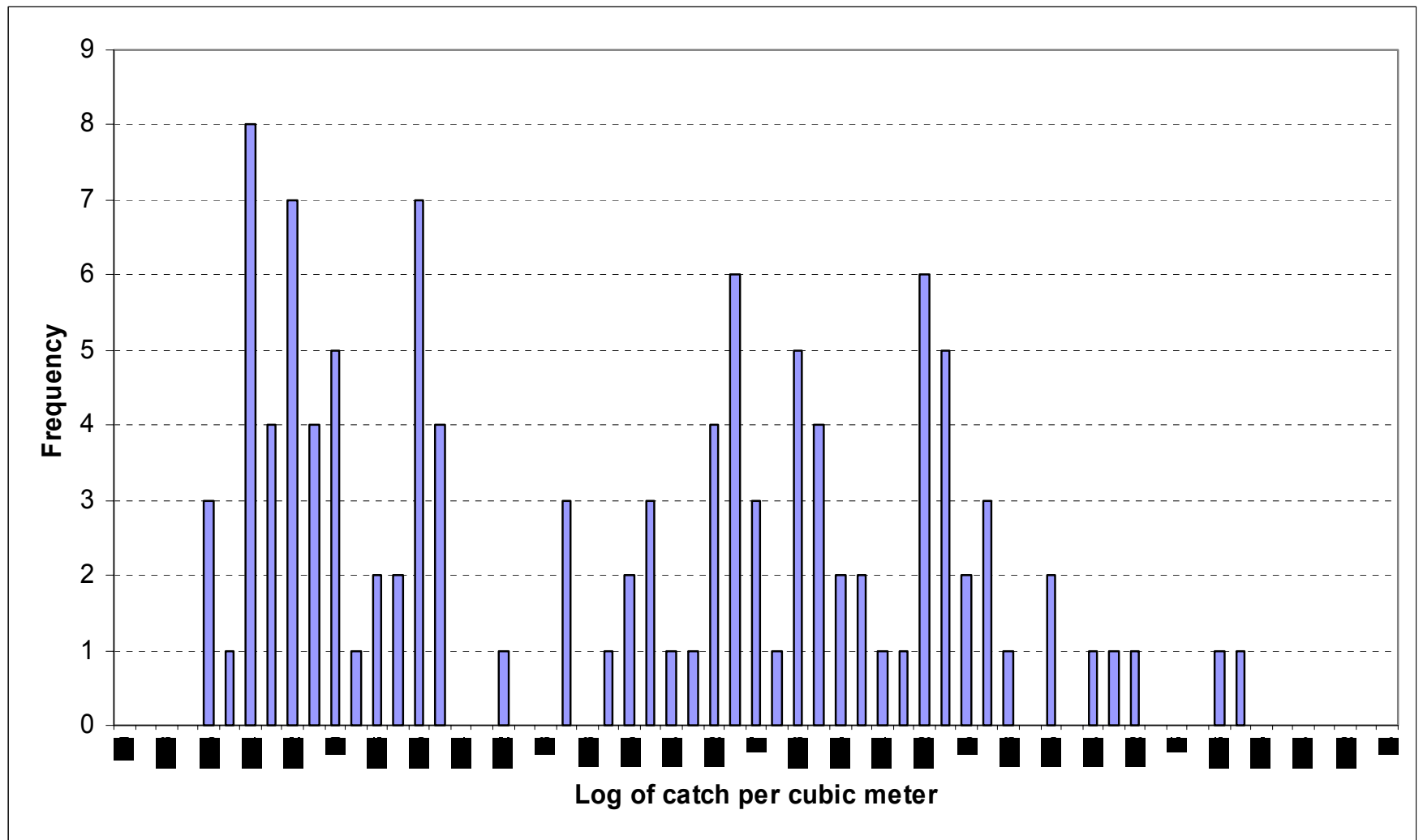


Figure 4. Frequency distribution of the natural log of catch/m³ by tow of marked and coded wire tagged (CWT) juvenile Chinook salmon for sampling at both trawl stations (SR027 and XC001) during both Replicate 1 and Replicate 2 for all tows where at least one marked or CWT fish was caught. Bins are based on an interval of 0.1.

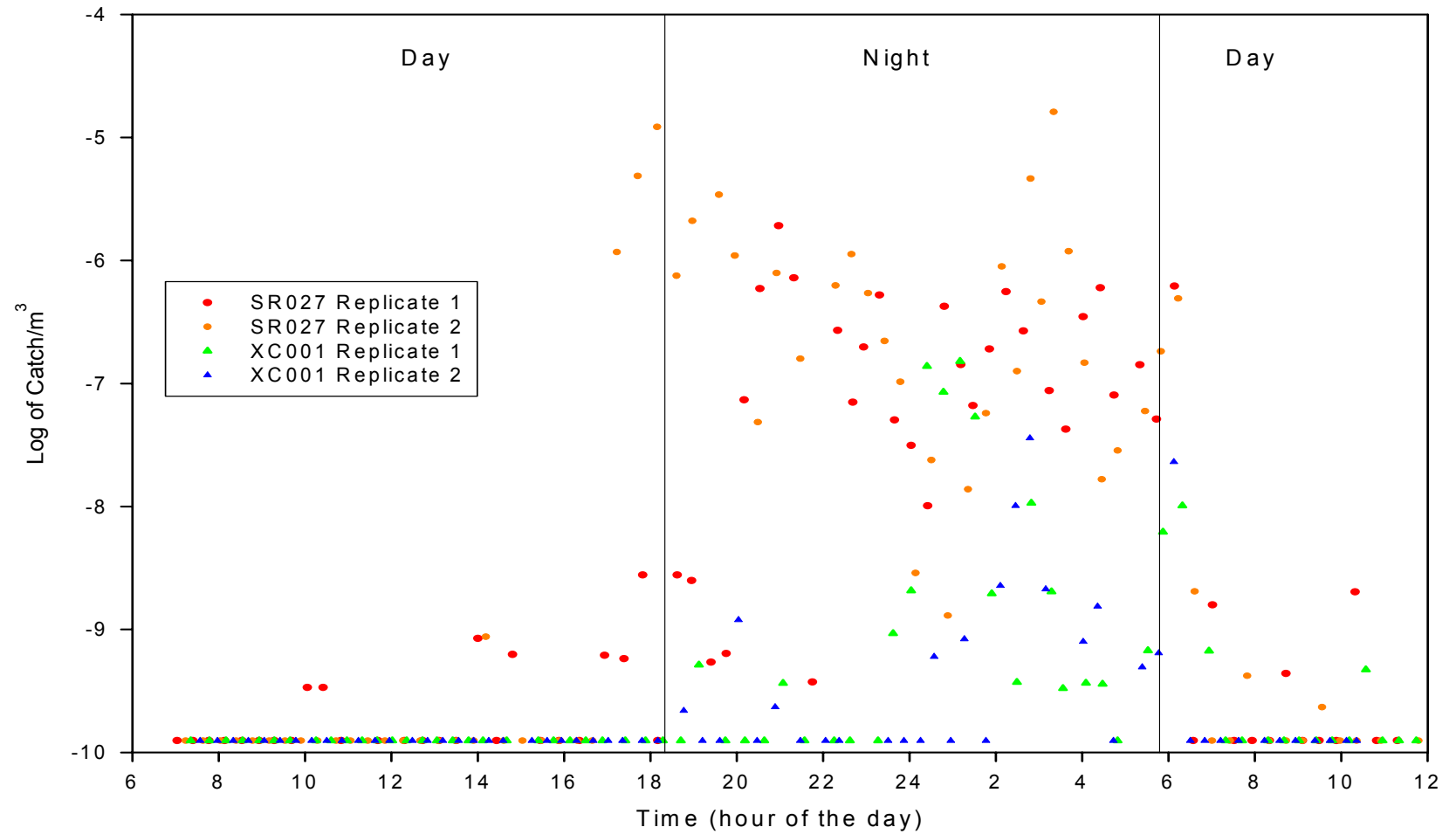


Figure 5. Scatter plot of the natural log of the catch/m³ of marked and wire tagged (CWT) juvenile Chinook salmon by tow captured at SR027 and XC001 during both Replicates 1 and 2. The X axis is the time of day that the tow began and covers a 36 hour period. Tows with zero catch of marked and CWT fish were included; these tows were assigned a catch/m³ of 0.01 times the lowest catch/m³ where a marked or CWT fish was captured.

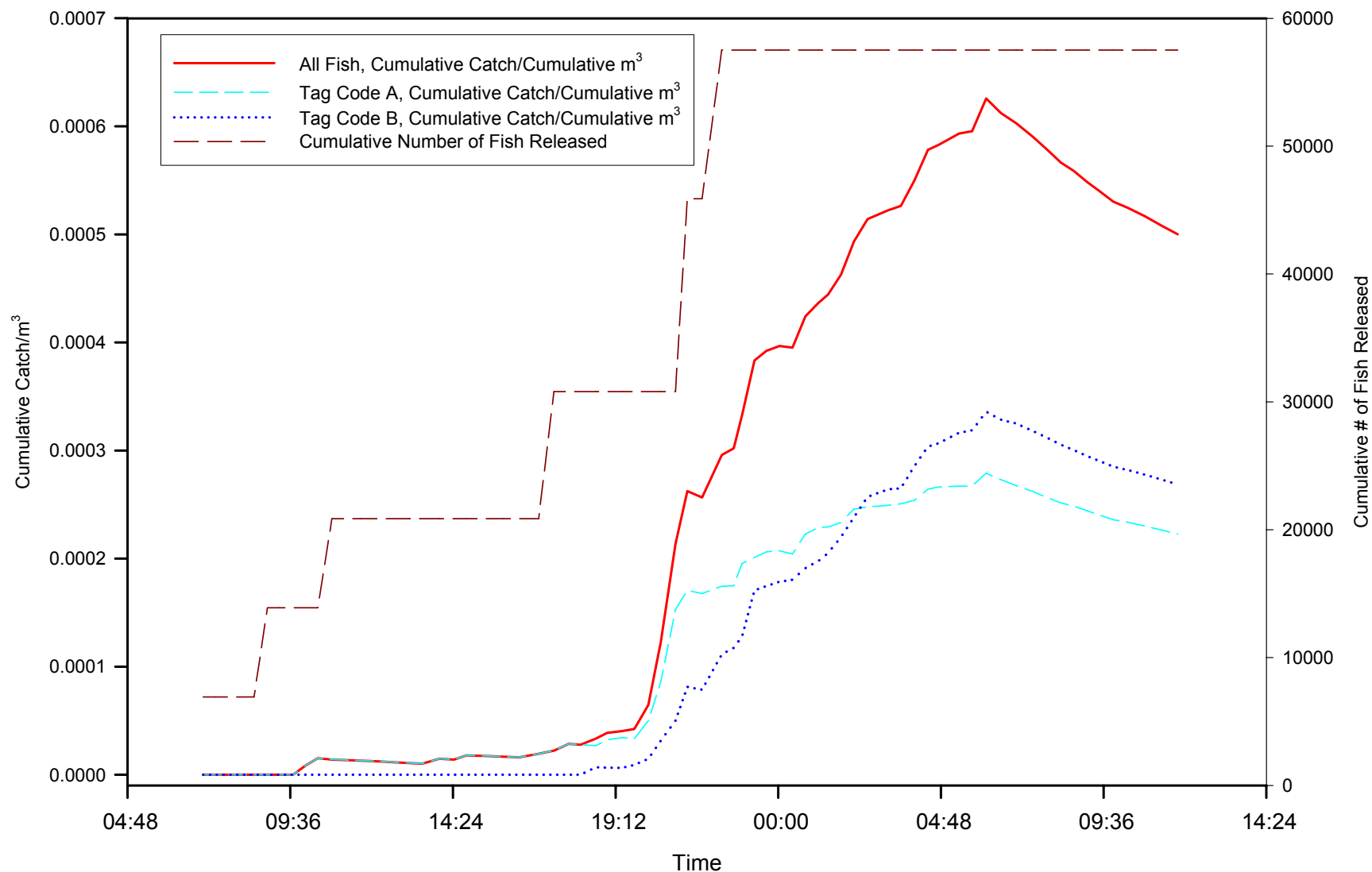
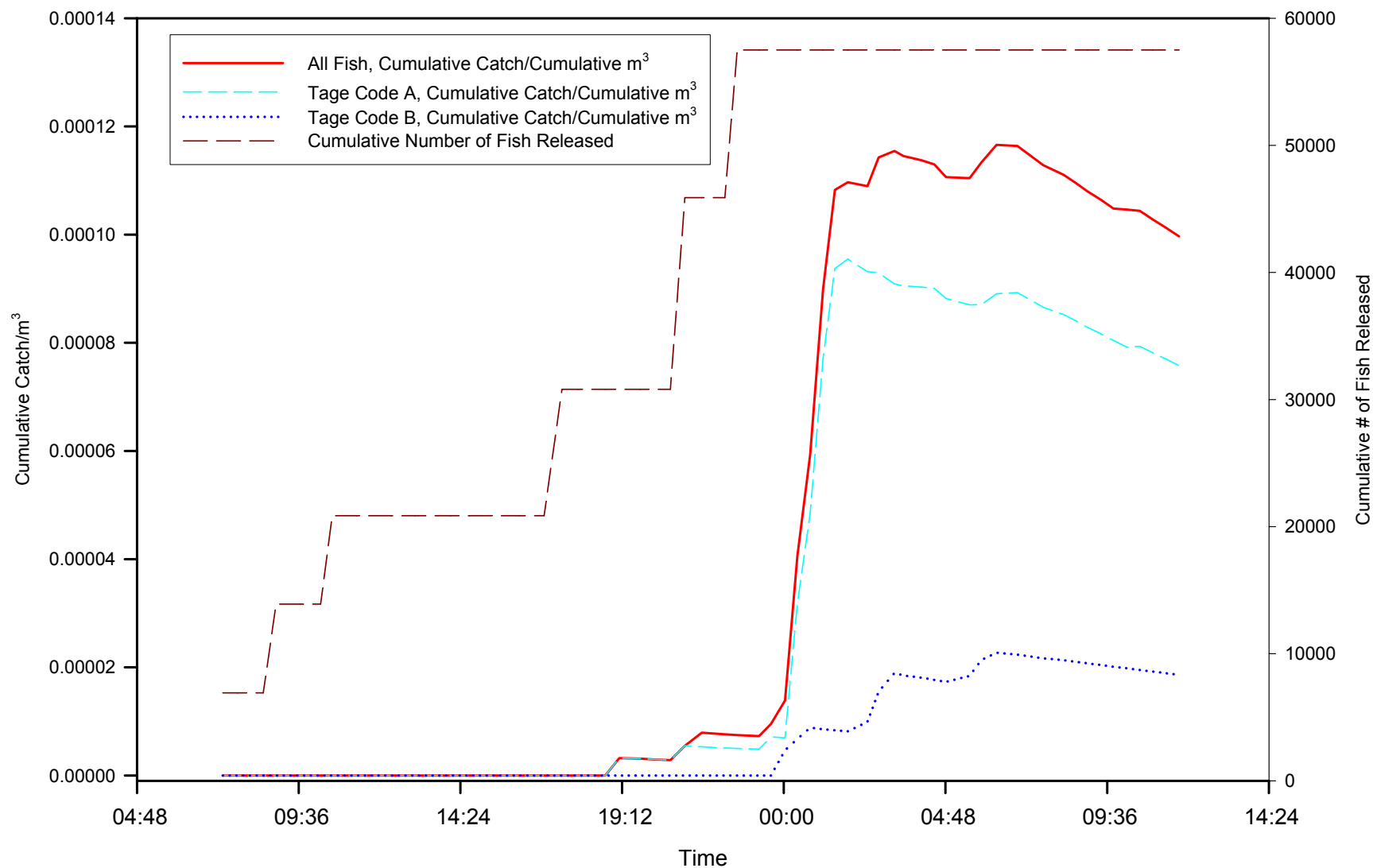


Figure 6a. Cumulative distribution of the catch/ m^3 of all marked and wire tagged (CWT) juvenile Chinook salmon, CWT code A fish, and CWT code B fish captured by tow at SR027, and the number of marked and CWT fish released during Replicate 1. Note the declines in catch/ m^3 result because it was calculated as the cumulative catch/cumulative m^3 sampled. The X axis is the time of day and covers a 36 hour period.



6b. Cumulative distribution of the catch/m³ of all marked and wire tagged (CWT) juvenile Chinook salmon, CWT code A fish, and CWT code B fish captured by tow at XC001, and the number of marked and CWT fish released during Replicate 1. Note the declines in catch/m³ result because it was calculated as the cumulative catch/cumulative m³ sampled. The X axis is the time of day and covers a 36 hour period.

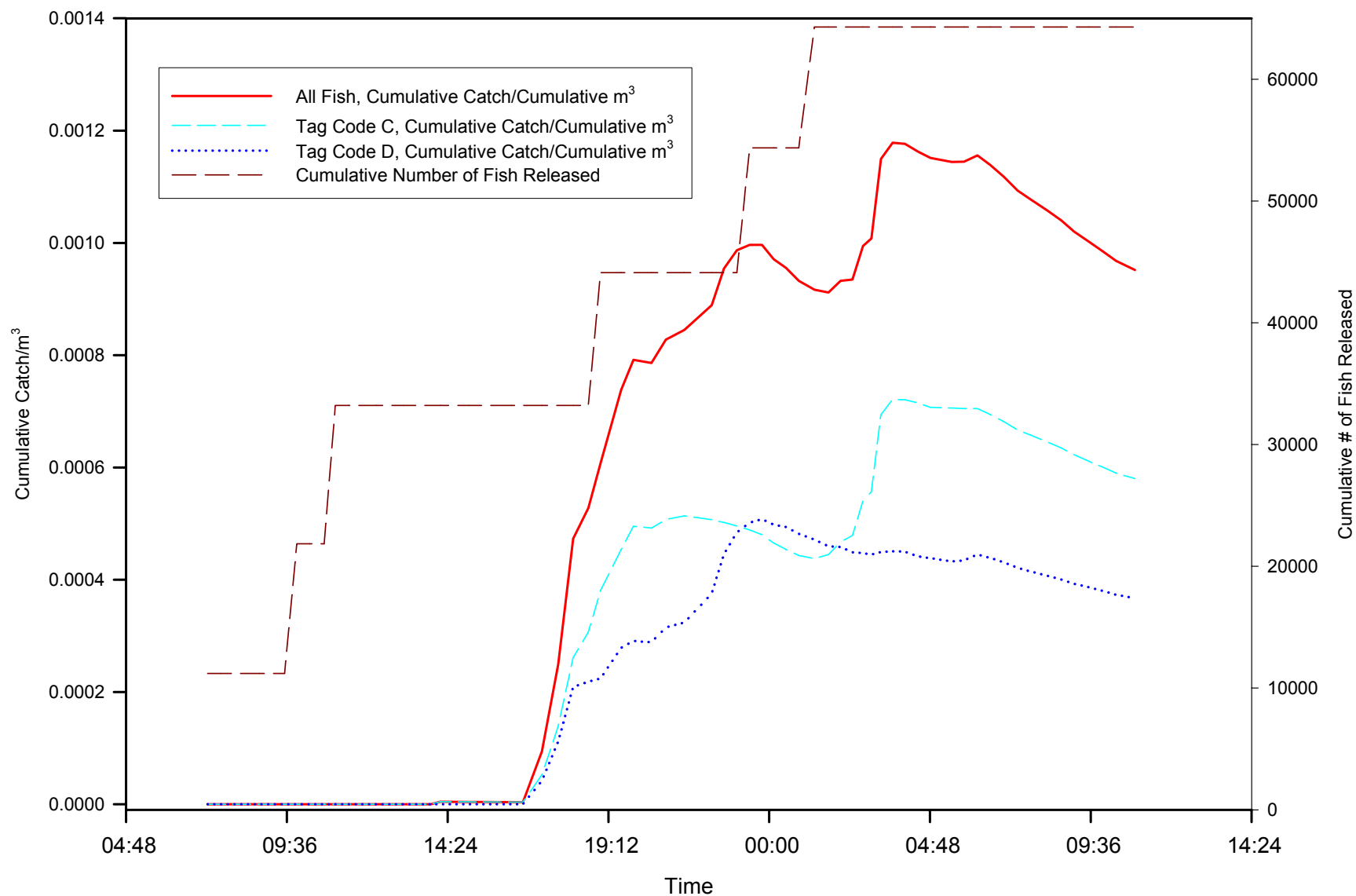


Figure 7a. Cumulative distribution of the catch/ m^3 of all marked and wire tagged (CWT) juvenile Chinook salmon, CWT code C fish, and CWT code D fish captured by tow at SR027, and the number of marked and CWT fish released during Replicate 2. Note the declines in catch/ m^3 result because it was calculated as the cumulative catch/cumulative m^3 sampled. The X axis is the time of day and covers a 36 hour period.

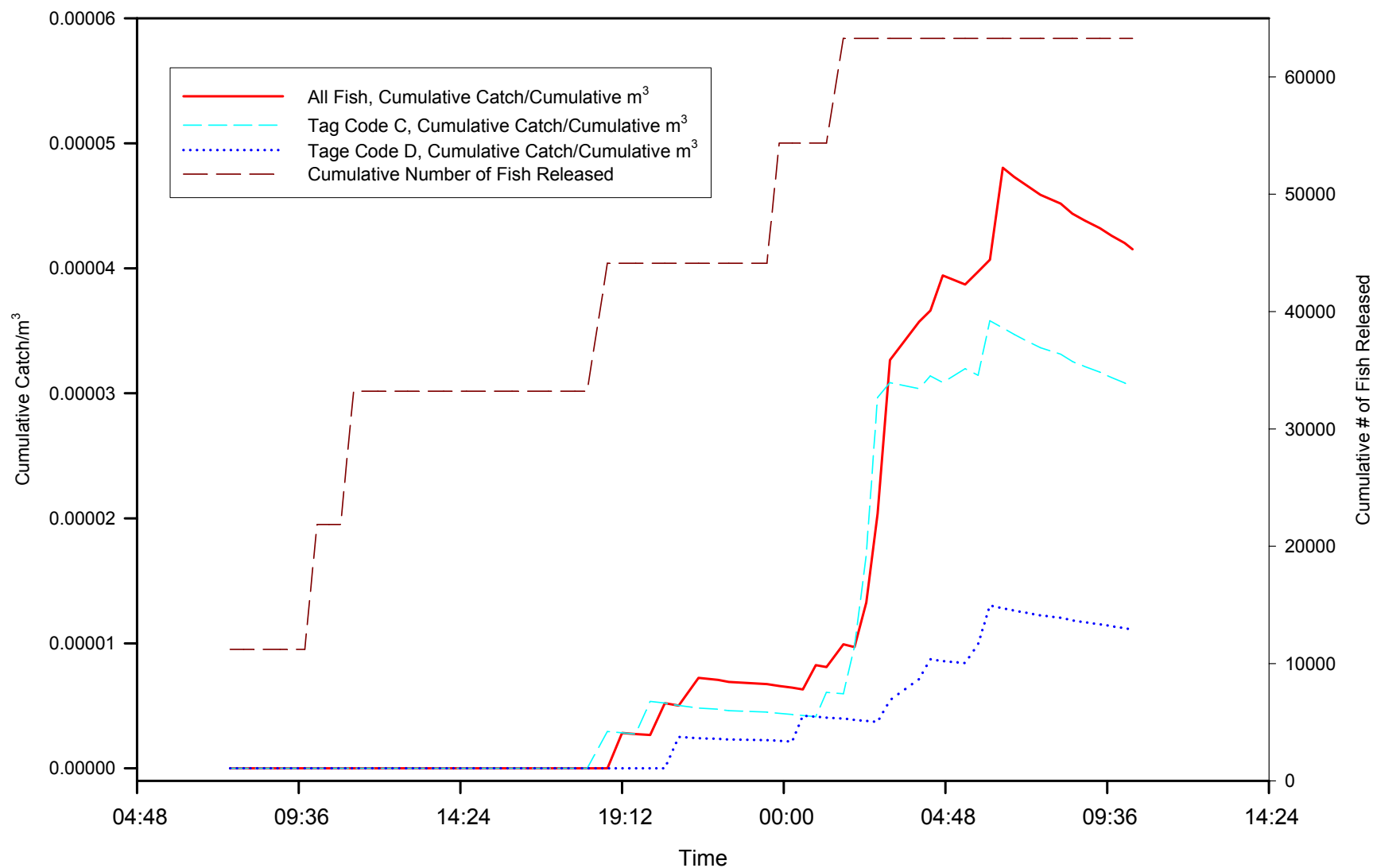


Figure 7b. Cumulative distribution of the catch/m³ of all marked and wire tagged (CWT) juvenile Chinook salmon, CWT code C fish, and CWT code D fish captured by tow at XC001, and the number of marked and CWT fish released during Replicate 2. Note the declines in catch/m³ result because it was calculated as the cumulative catch/cumulative m³ sampled. The X axis is the time of day and covers a 36 hour period.

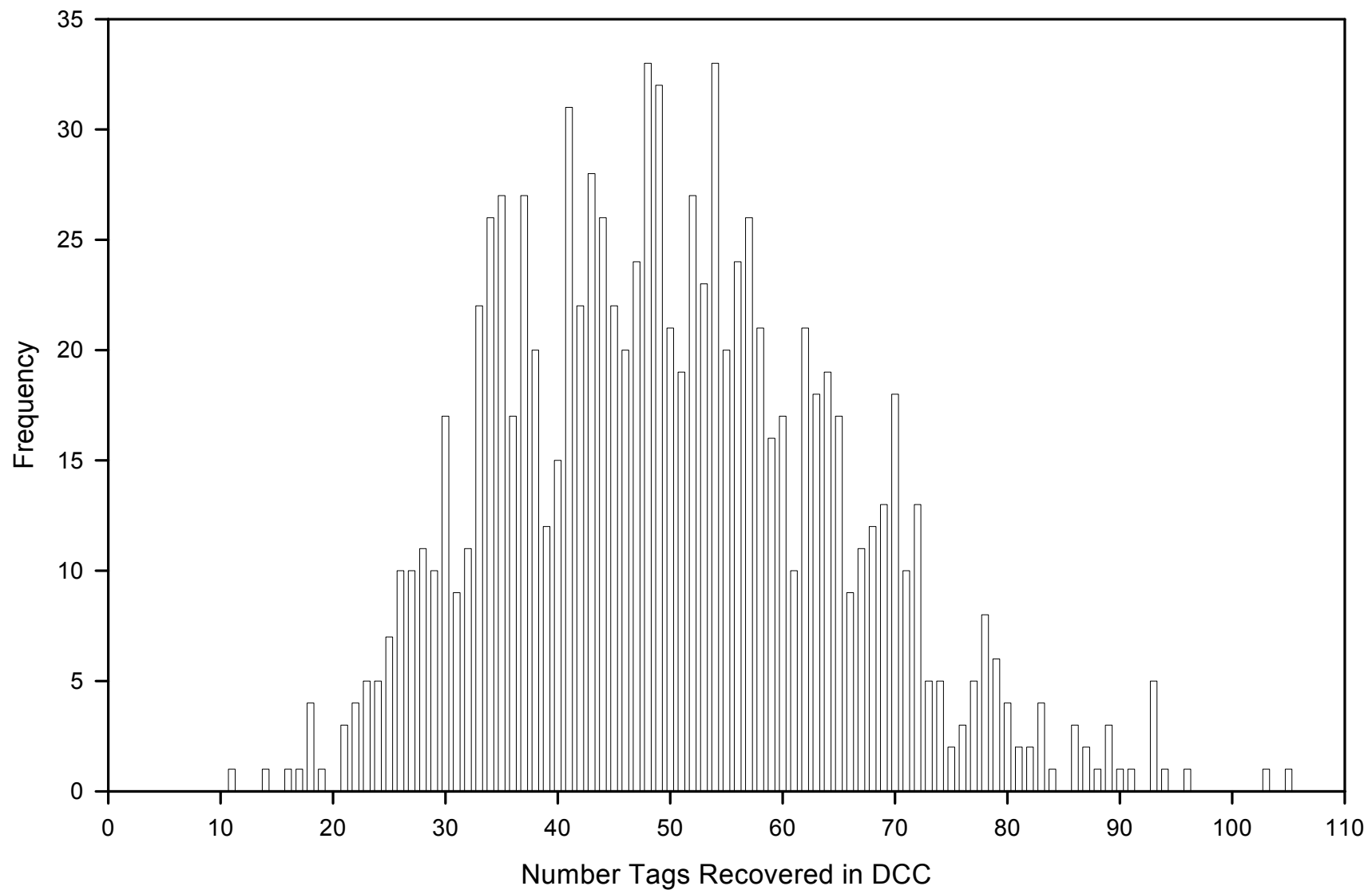
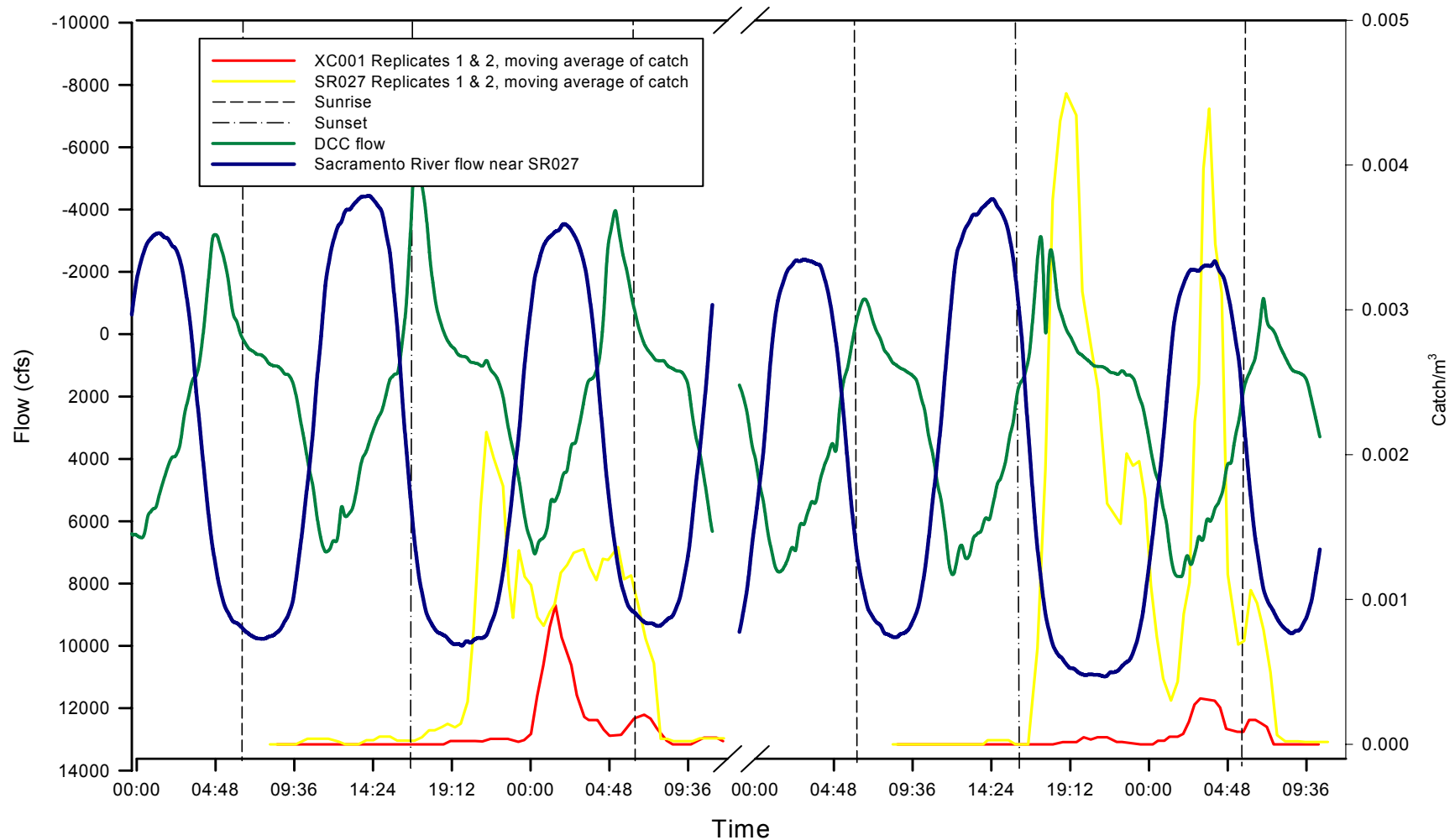


Figure 8. Frequency distribution of the numbers of coded wire tagged (CWT) juvenile Chinook salmon recovered in the Delta Cross Channel, generated by 1000 bootstraps, each which simulated sampling of Replicates 1 and 2.



Replicate 1

Replicate 2

Figure 9. Flows in the Delta Cross Channel (DCC) and the Sacramento River immediately below the DCC, and moving averages of the catch/m³ of marked and coded wire tagged juvenile Chinook salmon captured at each station during each Replicate. The moving average was calculated using four consecutive tows for each point. The scale for the left axis was reversed to indicate the relative tidal conditions; negative flows were associated with a flood (high) tide, and positive flows were associated with an ebb (low) tide. Note the break in the X axis which reflects the sampling periods of the two replicates and that the tidal conditions were out-of-phase between locations.